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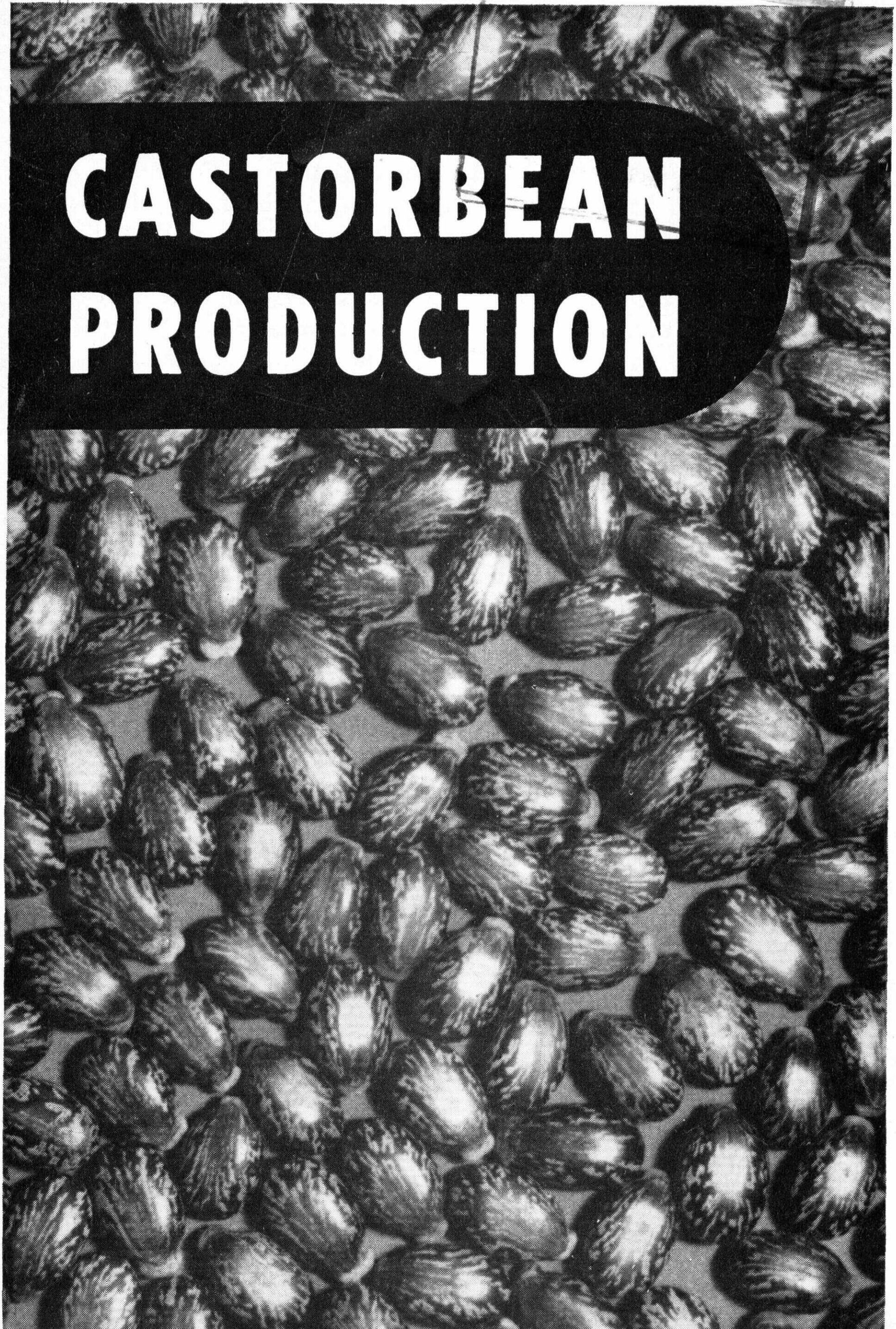
CASTORBEAN PRODUCTION



FARMERS' BULLETIN No. 2041

U. S. DEPARTMENT OF AGRICULTURE

CASTORBEANS and castor oil have been important items of commerce since Biblical times. For many years the oil has been used in medicine, printing, dyeing, and machine lubrication. Since the beginning of World War II chemists have found many new uses for castor oil and its derivatives. These products are now in extensive use for the manufacture of paints, plastics, rayon, textiles, nylon, hydraulic and recoil fluids, special lubricants, flexible coatings for electrical equipment, and many other special items.

In 1951, 75,000 acres of castorbeans were planted in the United States, 25,000 acres of which were grown under irrigation in California and Arizona and 50,000 on dry land in Oklahoma and Texas.

The crop requires a growing season of 150 to 180 days to produce satisfactory yields. It can be grown in regions with as little as 15 to 20 inches of summer rainfall if the moisture is well distributed. Much better yields are obtained where the rainfall reaches 35 inches a year. In sections where all of the water is supplied by irrigation, 3 to 3½ acre-feet of water are required to produce good yields. Excessive rainfall and high humidity result in serious diseases and harvesting hazards.

Castorbeans, if eaten, are poisonous to people and livestock. No case has been definitely established of livestock being poisoned by eating the leaves and stems; however, most animals avoid eating these parts unless forced to by lack of other food.

Detailed information concerning contracting agencies, recommended varieties, location and cost of seed, and market value is not included in this bulletin. Federal, State, and county PMA offices, State agricultural extension services, and county agents will ordinarily be able to supply this and other information needed by prospective growers of castorbeans.

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CASTORBEAN PRODUCTION

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Contents

THE CASTORBEAN plant is grown for its seed, which contains about 50 percent oil. Commercial crops are grown largely in Western States, owing to the prevalence of the gray mold disease that attacks the plants in eastern and southeastern sections.

The seed and oil have been important items of commerce since Biblical times. The oil now is used mainly as a raw material in the manufacture of many materials needed for military and defense production and other products in everyday use. Important uses are for lubrication of jet airplane engines, all-purpose greases, hydraulic and recoil fluids, and plastic coatings for electrical equipment. It is also used as a plasticizer in the manufacture of fabrics and explosives. Other uses are in the manufacture of artificial leather, soap, printing ink, and special low-temperature lubricants and flexible coatings. The largest single consumer is the protective-coating industry, in which, after dehydration, castor oil is used as a quick-drying base for paints,

lacquers, and varnishes. It is the chief raw material for the production of sebacic acid, the basic ingredient in the synthesis of nylon plastic.

The press cake remaining after the oil is removed from the seed is known as castor pomace. It is not usable for livestock feed, because the poisonous constituent in the castorbean remains in the pomace during the crushing process. Although it is possible to detoxify the pomace, the cost of assaying each batch to be sure it is nontoxic prevents use of the process at present. All of the castor pomace resulting from crushing operations in the United States is used either as an organic fertilizer alone or as a high-nitrogen filler in commercial fertilizer mixtures.

Since 1940 the United States has imported between 250 and 300 million pounds of castorbeans annually. Beginning in 1950 the imports of castorbeans have declined slightly, however, and the importation of castor oil has increased to about 60 million pounds at the end of 1951.

World castorbean production in 1951 was about 960 million pounds, which was slightly less than the 1950 world production. The all-time high in the world castorbean output was attained in 1948, when an estimated 1 billion and 90 million pounds were produced. Brazil is the largest producer of castorbeans, followed closely by India. The Soviet Union ranks third, and in 1951 the United States was fourth.

CASTORBEAN PRODUCTION IN THE UNITED STATES

From 1870 to about 1910 castorbeans were grown commercially in several of the Midwestern States, particularly in Kansas. In 1879, the year of maximum production, about 35 million pounds of beans was produced in the southeastern counties of Kansas, with the acreage declining gradually thereafter. Production had virtually ceased by 1910, probably owing to continued low returns to the grower. The average yield in the several Kansas counties was seldom above 400 pounds per acre, and the value of the beans in most years was not more than 3 cents per pound. The decline in production in the Midwest was accompanied by a shift in the location of castor oil mills from the Central States to the Atlantic seaboard. With this shift came the use of imported beans.

During World War I, the Bureau of Aircraft Production of the War Department undertook an extensive domestic castorbean production program to procure adequate supplies of castor oil for airplane engines. This attempt at production did not get under way until 1918, and all interest in the project ceased with the end of hostilities. Lack of information and seed adapted to the area, use of poor land, and neglect of the crop by growers led to low yields. In spite of these difficulties about 11½ million pounds of beans was produced in 1918.

During World War II another attempt was made to promote castorbean production in the United States. Some 3 million pounds of seed was produced in 1943, after which production was discontinued. During 1943, the supply of imported beans again became adequate, and no further attempt was made at domestic production during World War II. However, during this period of interest, adapted strains were selected and valuable information was obtained on areas of adaptation, soil and fertility requirements, and production methods.

After the end of the second wartime production program the United States Department of Agriculture realized that castor oil would probably be a critical material in any future national emergency. The Department, therefore, retained its plant-breeding project and maintained seed stocks of adapted varieties of castorbeans. In 1947 a commercial castor oil crushing company, needing a stable supply of raw material, set up its own agronomic division to attempt to develop castorbean production in the United States on a sound peacetime basis. By 1950 the efforts of this company had led to an annual planting of about 7,000 acres, mainly for the increase of improved varieties of seed. This source supplied seed of adapted varieties, which were used to plant some 75,000 acres of castorbeans in 1951. About 25,000 acres were grown under irrigation in California, Arizona, Oklahoma, and Texas, and about 50,000 acres on dry land in Oklahoma and Texas.

NATURE OF THE PLANT AND SEED

The term "castorbean" is used to refer to both the plant and seed of *Ricinus communis*, a member of the Euphorbiaceae, or spurge, family. The plant as grown for commercial production in the United States is an annual, 3 to 10 feet in height, with few to many racemes (flower clusters) on which the seeds are borne in three-parted capsules. Color of the plant or seed has no bearing on its commercial value. Neither does the size of the seed have any relationship to the oil content, except that the large-seeded ornamental types usually are low in oil.

The female flowers, which develop into the capsules with seed, are borne on the upper part of the raceme with the male flowers below them. The raceme is commonly called the spike (fig. 1). After the pollen is shed, the male flowers dry up and drop off, which accounts for the lower part of the spike stem usually not bearing fruit.

Most of the ornamental types forcibly eject the seed (dehisce) at maturity, while commercial varieties retain the seed for a time. Under adverse weather conditions the capsules of the commercial varieties tend to open, with resulting loss of the seed (shattering), or the capsule may fall or be broken off as a unit (dropping).

The seed somewhat resembles a bean, except that it is obovoid rather than kidney-shaped and has a prominent enlargement at one end, called the caruncle. This is the place of attachment of the immature seed and serves no purpose after maturity. The plant is not a legume and has no soil-improving value other than the beneficial effect usually noted when an additional crop is included in the rotation, rather than growing the same crop continuously.

TOXIC PROPERTIES

Castorbeans, if eaten, are poisonous to people and livestock. Care should be taken that children do not eat the attractive seeds and that seeds are not mixed with human food or grain fed to livestock. No case has been definitely established of livestock being poisoned by eating the leaves and stems; however, most animals avoid eating these parts unless forced to do so by lack of other feed. Castor oil used for medicinal purposes is obtained from the seeds by processes not adaptable to home use. Commercial processes exclude the

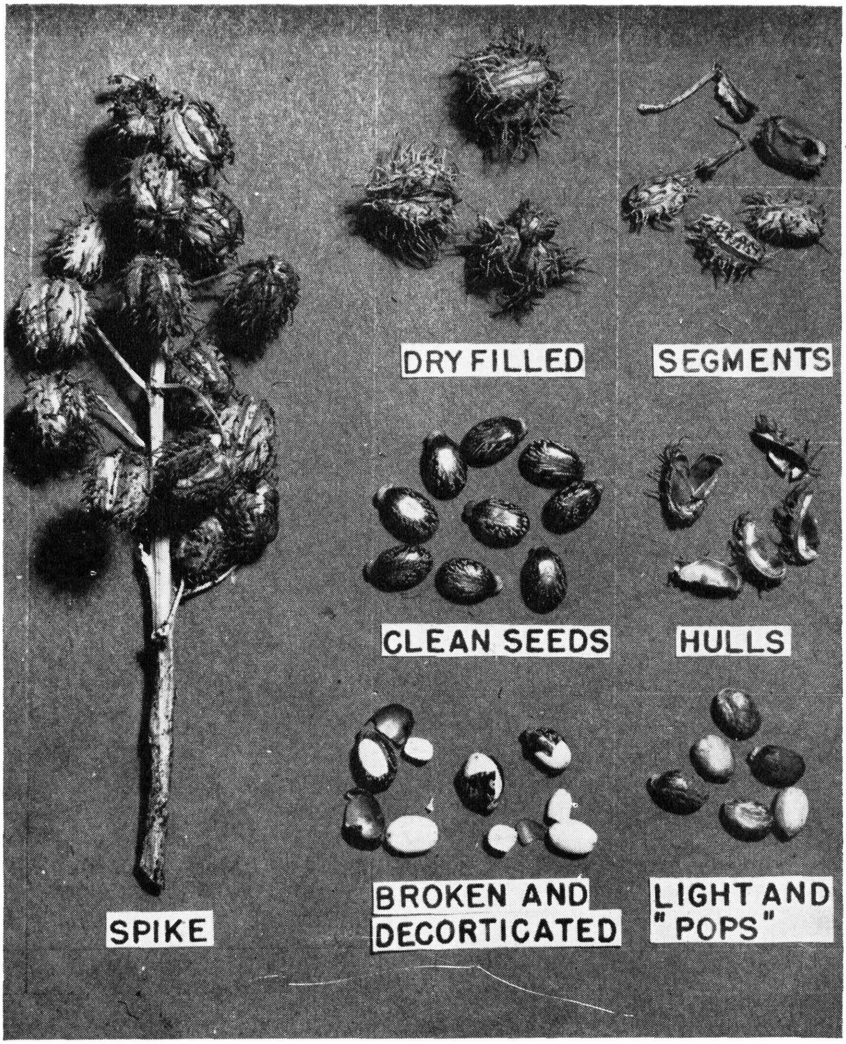

Figure 1.—*Castorbean spike, capsule, and seed parts.*

poisonous constituents from the oil. Because of these poisons, castorbeans should not be stored with livestock or human food or processed with the same machinery or on the same premises with other oils for food. Anyone offering such contaminated products for sale is subject to the penalties of the Federal Food, Drug, and Cosmetic Act and to certain regulatory acts enforced in most States.

Castorbeans also contain a substance that causes allergy in some people. Cases have been reported where inhaling dust from castorbeans, either in mills where the oil was being extracted or in fertilizer factories where the pomace and pressed cake was being handled, caused severe allergic reactions. It is not known what proportion of persons handling castorbeans are likely to develop sensitivity, but the number is believed to be relatively small.

CLIMATIC AND SOIL REQUIREMENTS

Length of Growing Season

Where castorbeans are grown under dry-land conditions a period of 150 to 180 days between the planting date and the first heavy frost in the fall is required to produce a satisfactory yield. Production of maximum yields under irrigated conditions in Arizona and California requires a full growing season of about 270 days. A summer crop, however, is sometimes produced with somewhat lower yields in about 150 days, planting being in the middle of the summer and harvest being delayed until after the first freeze.

Temperature

As castorbeans are of tropical origin they tend to do best in areas where the temperature remains fairly high during the entire growing season. However, they suffer from extremely high temperatures. Blasting of the flowers and failure to set seed usually occur when the temperature exceeds 105° F., particularly if the soil moisture available to the plants is low. This failure to set seed may occur under dry-land or irrigated conditions whenever high temperatures and high evaporation rates produce moderate to severe wilting of the leaves and if moisture stress is so severe as to cause any wilting of the flowering spikes.

Moisture Requirements

At least 15 to 20 inches of summer rainfall is required for satisfactory yields under dry-land conditions, and rainfall as low as this must be well distributed. Dry-land areas where the rainfall reaches 35 inches per year are much better adapted. Under irrigation 3 to 3½ acre-feet of water applied at the proper times during the growing season will produce a good yield, the amount needed varying somewhat with local conditions.

Soil Requirements

Although the castorbean crop will give fair response on many different soil types, best yields are obtained only on soils that have (1) good drainage; (2) no compact or impervious layers or claypans; (3) ability to warm up early in the spring; and (4) good moisture-storage capacity. Soils subject to destructive erosion should not be used, for this crop has little soil-binding ability. The crop succeeds on either calcareous or acid soils.

Disease Limitations

Extensive experiments in the Atlantic and Gulf Coast States indicate that castorbeans suffer so much from a destructive disease called gray mold, caused by *Sclerotinia ricini* Godfrey, that it is too risky to attempt production in these regions. Furthermore, when the crop is grown anywhere in the subhumid area of the Eastern States, the pedicels (stems) that attach the capsules to the spike stem are so severely attacked by *Alternaria* sp. that the pedicels often break

and thus cause severe loss from dropping. If harvest is delayed too long after the seed matures, the seed itself may be destroyed by this fungus. For these reasons the area of adaptation for castorbeans does not at present include either the Atlantic or Gulf Coast regions or any of the other States east of the Mississippi River.

CROPPING SYSTEMS

In Cotton, Corn, or Peanut Areas

Since castorbeans are produced as an annual row crop, they can replace cotton, corn, grain sorghum, or peanuts in the rotation. In areas where no rotation is practiced, yields of both cotton and castorbeans have been benefited by rotating the two crops. Where a legume is included in the rotation, castorbeans should not immediately follow it; many of the varieties available at present will grow too tall if abnormally large supplies of organic nitrogen are available, particularly in seasons of unusually high rainfall. Castorbeans succeed quite well in the peanut areas of Oklahoma and Texas, but it should be remembered that they need at least as much commercial fertilizer as a crop of peanuts. Some farmers grow castorbeans in strips in the peanut field to reduce wind erosion. It has been observed also that castorbeans planted in strips in the cottonfield reduce the wind movement in the area of the growing crop and appear to protect the cotton from hot drying winds.

Under Irrigation in Arid Valleys of California and Arizona

In California and Arizona castorbeans fit into any cropping system where a summer annual crop is possible. Thus, they may replace cotton or grain sorghum. One popular system of growing castorbeans, however, is to double-crop with winter-grown small grain, flax, or vegetables, the castorbean being in the field from July to December. Some growers also double-crop with winter vegetables such as lettuce, cantaloup, or carrots. In the San Joaquin and Antelope Valleys of California, where the growing season is shorter than in the Imperial Valley of California and the Yuma and Salt River Valleys of Arizona, castorbeans must be planted early and harvested before high winds and cold wet weather of the fall season damage the crop.

VARIETIES

Tall (Dry-Land Type)

Of the castorbean varieties now available for commercial use, only the Conner variety is restricted to dry-land production. However, it may grow too tall under favorable growing conditions, and it is normally late in maturing, setting its first spike at the twelfth to fourteenth node (fig. 2). When high acre yields are produced from using the Conner variety, harvesting difficulties are almost always encountered, owing to the extreme plant height.

Figure 2.—Conner plants, with capsules beginning to mature.

Figure 3.—Variety U. S. D. A. 74, used both on dry land and under irrigation.

Intermediate (Dry-Land or Irrigation Types)

Two of the present varieties—U. S. D. A. 74 and Cimarron—might be called intermediate in plant growth and have been used on both dry land and under irrigation. U. S. D. A. 74 was grown under irrigation in California in 1949 and in Oklahoma in 1950 and 1951 (fig. 3). It is an early variety, flowering at the seventh or eighth node, but may grow too tall for convenient harvesting when adequate soil moisture and nitrogen are available. This variety suffered severely from an extreme summer drought when it was grown on nonirrigated land in Oklahoma in 1951. U. S. D. A. 74 appears to be unable to withstand extended periods of drought and hot weather, and it

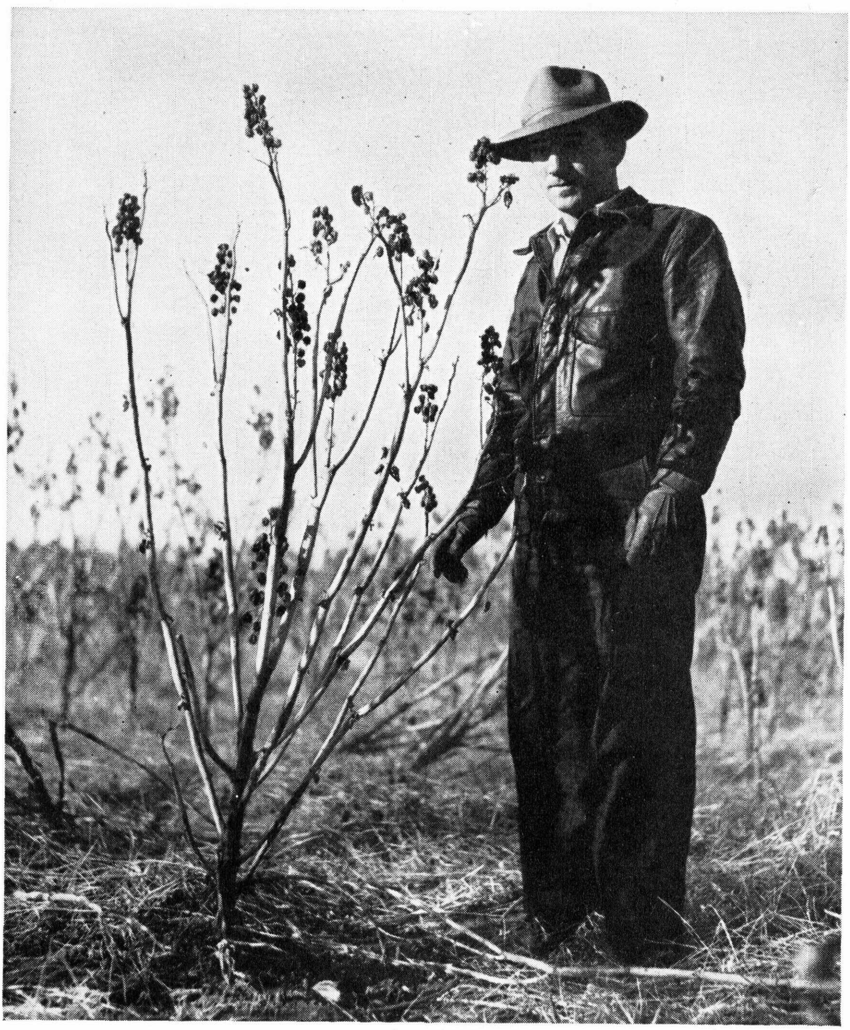

Figure 4.—*Mature Cimarron plant with leaves removed, showing arrangement of spikes. Such a plant is easily harvested by the stripper harvester.*

should be planted only in areas where moderate temperatures and adequate rainfall are the rule.

Cimarron has recently become a popular variety in the Midwest. It is moderately late, flowering at the eleventh or twelfth node, but under Oklahoma or Texas conditions it usually does not produce excessive plant height (fig. 4). When grown under irrigation Cimarron may possibly grow too tall for convenient hand harvesting, but it can be harvested with presently available harvesting machinery. The main advantage of this variety is its ability to withstand shattering or dropping, thus making possible a single machine harvest at the end of the growing season. Under favorable growing conditions Cimarron may produce very high yields when an extreme summer drought does not occur.

Short (Irrigation Types)

Four varieties—Baker 1, Baker 7, Baker 34, and Baker 195—have recently been used for commercial production in the irrigated valleys in California and Arizona, and they also appear to be successful under irrigation in Oklahoma and Texas. These varieties were selected for their fine stems and low bushy growth, which make them particularly well adapted to combine harvesting (figs. 5 and 6). The plants set the first spike at about the fifth or sixth node, and since they branch considerably they bear many small spikes. Under adequate growing conditions it is quite possible for these strains to

Figure 5.—*The small spikes and fine branching habit of the Baker dwarf variety are well adapted to combine harvesting.*

Figure 6.—Baker dwarf variety growing under irrigation in Imperial Valley, Calif.

yield more than 3,000 pounds of hulled seed per acre. Of the four varieties Baker 34 appears to be most uniform, but this may account for its somewhat lower yield. Baker 1 is not genetically pure, producing a number of rogues, or offtype plants, but it seems to be better adapted to a variety of soils and climates and has given slightly higher yields. Baker 7 gave good yields in the High Plains area of Texas. Baker 195 was tested for the first time in 1951, and it gives indications of being the highest yielder of the four.

New Varieties

New improved varieties are being developed and tested by the United States Department of Agriculture, by State agricultural experiment stations, and by private agencies. The production of hybrid castorbean seed is in the introductory stage.

Importance of Pure Seed

Commercial varieties of castorbeans are at present inbred strains, produced by continued selfing until genetic purity was approached. Several of these strains when cross-pollinated produce abnormal plants in the advanced generations. This is particularly true of Conner and U. S. D. A. 74. In the crops produced in years after crossing of these two varieties, a larger and larger number of tall single-spiked plants will be produced. Many of these plants flower very late in the season and may never produce a spike in time for maturity before frost.

These plants are very undesirable; they reduce the average yield, owing to competition with normal plants, and their extreme size makes harvest with machinery difficult. Pure seed is also important to the huller. Established varieties produce seeds of relatively uniform size. When different varieties are allowed to cross, variation in seed size results and the variable seed is extremely difficult to hull. Because of these objections to the mixing of varieties, a pure-seed program, and possibly a certified-seed program, is essential to the continued success of castorbean production in the United States.

PLANTING

Seed Cleaning and Treatment

One of the most important steps in obtaining high yields is to get a uniform stand of plants at the desired spacing. To help get this desired stand castorbean seeds used for planting should be recleaned with a fanning mill to remove all foreign material, castorbeans with attached hulls, and light, broken, or decorticated seeds. As far as is possible with the somewhat variable seed size and shape characteristic of most varieties, it is desirable to grade the seed by removing small and oversized seeds to make seeding more uniform by mechanical planters.

Present practice in Texas and Oklahoma is to treat the seed after cleaning with sufficient Arasan (tetramethylthiuram disulfide) to prevent growth of seed-borne fungi. This treatment has value in protecting the seedlings from soil-borne diseases. If the seed was produced under conditions of low rainfall and low humidity at harvesttime, the seed-borne fungi are less noticeable and the seedsman may be tempted to omit the seed treatment. Seed treatment should not be neglected, however, particularly if the seed is to be planted in areas where there is risk of low temperatures and high soil moisture immediately after planting.

As the seed treatment material used is poisonous and objectionable when it comes in contact with the eyes, nose, or throat of persons handling the seed, the slurry seed-treatment method has been used to reduce the amount of dust. It is equally as effective as the dust method in improving germination and stands.

Time of Planting

If maximum yields are to be obtained castorbeans must be planted as soon as possible after danger of the last killing frost, in order to utilize the entire growing season. This date will vary from early March in southern California to as late as April 1 in Oklahoma. The best general rule is to plant castorbeans as soon as possible after the soil warms up sufficiently to insure prompt germination and rapid growth of seedlings. In areas where corn or cotton are the most common row crops this date will be about the same as the early planting date for those crops.

Rates of Planting

The rate of planting is controlled by the desired spacing or number of plants per acre, the number of seeds per pound, the germination

percentage of the seed, anticipated loss of seeds caused by breakage in the planter and to seedling disease, and loss of plants caused by destruction in cultivation. One fact cannot be overemphasized: Maximum yields of any crop cannot be obtained without an adequate stand. Good stands of castorbeans require rather heavy planting rates, mainly because germination of the seed is normally rather low (often as low as 75 percent) and because high breakage may be caused by unadapted planters. Ten pounds per acre are required to give good stands of the tall and intermediate varieties, and 12 pounds may be required of the short varieties. When labor for hand chopping is available it is desirable to plant more than the recommended rates and thin to the recommended stand. This stand is one plant per 24 inches for Conner, one per 20 inches for Cimarron, one per 15 inches for U. S. D. A. 74, and one per 12 inches for the several Baker varieties. The rates in pounds per acre recommended above provide about twice as many seeds as are called for by the recommended spacings. Infrequently, hand thinning may be required after planting at these rates.

Planter Boxes

Horizontal-, inclined-, and vertical-plate planter boxes have been used to plant castorbeans. Regardless of the type of planter box used, it is essential that the machine be adjusted so that it does not crack or crush the soft oily seed. If the machine is not properly adjusted, dirt will collect in the oil from crushed seeds, which causes plugging of the box and thus results in poor stands. The inclined- and vertical-plate boxes tend to cause less breakage, owing to their construction; therefore, they are generally recommended over the horizontal-plate box.

If the horizontal-plate box is used, the plates must have sufficient thickness and openings of the right size to prevent crushing of the seeds. In addition, it is usually necessary to substitute either a soft spring or a rubber- or stencil-brush-type cut-off and knock-out mechanism for the metal cut-off and knock-out pawls. The slip ring on which the plate turns also should be polished brightly so that a rough surface, caused by rust or rough casting, does not break the seed coat. When using the inclined- or vertical-plate boxes, it is still necessary to see that the cells, or cups, are of the right size and shape.

The county agricultural agent, the county PMA office, and the local equipment dealer should be consulted for recommendations on the kind of planter plate to be used in each planter box.

Type of Culture

Flat culture and nearly all variations of planting in the furrow, on sides of beds, and on top of beds are used by growers of castorbeans in various areas. The type of culture is usually dictated by the planting and cultivating equipment on hand and by the grower's familiarity with one particular method. However, irrigation, soil conditions, and proposed harvesting methods influence the planting and cultivation methods. Satisfactory stands can be obtained using flat culture if the seed is planted deep enough and covered with a sufficiently firm layer of moist soil to insure rapid germination. This will usually be between 1 and 3 inches. Castorbean seeds are large and require adequate soil moisture for germination. If moisture is not available,

the seed may dry out and either fail to emerge or fail to establish a root system. It is essential that the seed be planted in a moist zone if the moisture already in the soil is to be depended upon for germination. Where the crop is grown under irrigation or where water is available for supplementary irrigation, the seed may be planted in dry soil and irrigated up. If this procedure is followed the seed should usually be planted either on the side or top of beds, with irrigation furrows opened between the rows so that water will not run down the row itself.

In some irrigated sections in Oklahoma and Texas the usual practice in planting cotton is to plant the seed in the bottom of the furrow and run irrigation water down the furrow if soil moisture or rainfall is inadequate. If castorbeans are planted in this way, the grower should be careful to see that the irrigation water does not wash the seed out or cover it to extreme depth. He should also be prepared to break any crust that forms by using a rotary hoe attachment directly over the rows before the seedlings emerge. If washing of the seed and soil can be prevented and if the grower is prepared to break any crust that forms, the planting of castorbeans in the bottom of lister furrows is advantageous in that it helps the grower control early weeds and annual grasses that may give serious competition to castorbeans during the first few weeks after planting. It is also possible with this method of culture to throw more dirt against the stems of the castorbean plants, which may help prevent lodging later in the season.

In certain irrigated sections in California and Arizona where salt accumulation is a problem, growers have followed the practice of planting two rows 38 inches apart on top of a bed similar to that used for lettuce. Water is then run down a furrow on each side of the two-row bed and no furrow is ever opened between the pair of rows. Some growers feel that this procedure will cause the salt to concentrate between the rows rather than in the row and thus reduce damage to the plants. Castorbeans grown under this type of culture may have the major part of their root system on one side of the row or the other, depending on soil moisture conditions resulting from differing irrigation schedules.

Other growers prefer a single-bed system to the double-bed system. If salt accumulation is not a serious problem, the single-bed system of culture offers the advantage of permitting irrigation water to be run down alternate furrows at alternate irrigations. This system has some advantages, if, because of weed growth or for insect-control purposes, it is necessary to get into the field at the same time the irrigation water is being applied.

CULTIVATION

Castorbeans germinate and grow slowly for the first few weeks after planting, and thorough cultivation to eradicate weeds during this period is most important. If weeds and annual grasses are not controlled early, it may be impossible to control them later by mechanical methods, making expensive hand weeding necessary. For the first cultivations the rotary hoe, either as a unit that covers the entire soil surface or as a row attachment which covers only the few

inches on each side of the row, has proved to be a very satisfactory implement. Very few seedlings are destroyed by the toothed wheels of the rotary hoe, and the weed control and breaking of crust obtained by its use may make the difference between a crop that is profitable and one that is not.

Although the castorbean plant has a taproot, it also has a widespread shallow fibrous root system that appears to be much more important than the taproot in obtaining moisture and nutrients from the soil. For this reason it is desirable to cultivate in such a manner that the fibrous root system is not disturbed. This means that cultivation should be as shallow as possible and cultivator shovels or sweeps should be kept as far from the rows as possible while still moving enough dirt to control weed growth. Obviously, the number of cultivations should be kept to a minimum, if little weed growth occurs and it is not necessary to hill up the plants to prevent lodging. Since hand hoeing is expensive, cultural methods should be aimed at making this practice unnecessary. If grassy weeds gain a foothold, however, it is usually more economical to control them with hand labor than to take the loss in yield that will result if they are left in the field.

FERTILIZATION

Organic Matter

Castorbeans are not a poor-soil crop and will not produce satisfactory yields on soils that are so low in fertility that they will not produce satisfactory yields of other crops commonly grown. The most important factor in the fertility level is the supply of organic matter, particularly organic nitrogen, in the soil. If the organic-matter level in the soil is known to be low, castorbeans should not be planted. On the other hand, very light or sandy soils will produce good yields of castorbeans if a good supply of organic matter has recently been worked into the soil.

Commercial Fertilizers

Many soils require the addition of commercial fertilizers. In general, if commercial fertilization is required for the production of cotton, peanuts, or other row crops, then an equal quantity of fertilizer should be used for the production of castorbeans. This application should be made with fertilizer-placement equipment, putting the material 2 to 3 inches below and 2 to 3 inches to one side of the row of seed at planting time. If the plants show a nitrogen deficiency in the form of stunted growth or yellowing of the upper leaves at some time during the growing season, an additional side dressing of commercial nitrogen should be applied. In irrigated areas this may be applied at any time during the growing season when the nitrogen deficiency becomes apparent by adding the commercial nitrogen to the irrigation water. If one of the tall or intermediate varieties is being grown, the supplemental side dressing is usually made at the final cultivation.

IRRIGATION

Irrigation practices and requirements vary widely throughout the areas in which castorbeans are produced. In the irrigated sections

of California and Arizona where castorbeans are grown on land that would otherwise be producing cotton, flax, or small grains, the water requirement is about 30 to 36 inches per year. This will vary according to the soil type, temperature, wind movement, and length of growing season.

In general, castorbeans require as much or very nearly as much irrigation water as does a crop of cotton under the same conditions. However, with castorbeans the irrigation water requirements will be higher in the early part of the growing season than with cotton, as castorbeans grow more rapidly and have a greater leaf area exposed earlier in the season. In the High Plains of Texas and in the irrigated sections of Oklahoma, where supplemental irrigation is practiced, the water requirement may be less than in California and Arizona, where the entire supply is added in the form of irrigation water. Depending on the amount and distribution of natural rainfall, 12 to 20 inches of irrigation water put on in two to four applications as required to prevent wilting may be sufficient in Texas and Oklahoma.

Irrigation water should always be applied in the furrow between the rows, not down the rows after the plants are up. Castorbeans do not stand "wet feet" for any extended period of time, and over-irrigation may cause undue loosening of the soil and result in severe lodging.

If salt accumulation is a factor, then all precautions taken to prevent salt accumulation with other crops must be practiced with castorbeans, including those mentioned under Type of Culture (p. 13).

The irrigation schedule should be so arranged that the plants never wilt severely. The crop should be watched closely and water applied at the first signs of wilting. Under conditions of no rainfall, of high temperature, and particularly of high winds, this may require an irrigation schedule of once each 7 to 10 days during the period in which the plants are growing most rapidly. If at any time the flowering spikes are permitted to wilt, blasting of the flowers and resulting loss of seed set will occur.

INSECTS AND DISEASES

So long as only a few acres of castorbeans were produced in any community, the insect problem did not appear serious; however, with rapidly expanding acreage, damage from several insects has been observed. When such damage occurs, steps should be taken to control the infestation. The most serious insect damage has come from cutworms and corn earworms, which attack the young seedlings, even to the extent of climbing young plants and eating the leaves and the first spike. These insects can sometimes be controlled with poison bait or by spraying with commercial insecticides. The local county agent should be consulted at the first signs of damage from worms of this type.

Scattered damage has been caused by green stink bugs and by the false chinch bug. Again, if the infestation shows signs of becoming serious, the county agent should be consulted for control measures.

Castorbeans are affected by certain diseases. Alternaria blight particularly is especially prevalent when the crop is grown under conditions of high rainfall or high relative humidity. Various soil- and

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seed-borne fungi cause damping-off of the young seedlings, and the seed-treatment practices mentioned earlier will help control these fungi. In areas of high relative humidity, such as the Gulf Coast and Atlantic Seaboard States, gray mold attacks the spikes and destroys the seed. The growing of castorbeans in these areas cannot be recommended until some method has been found for combating this disease. The castorbean plant is susceptible to the Texas root rot organism, and castorbeans should not be planted where this disease is prevalent on cotton. The castorbean plant appears to be tolerant to the verticillium wilt organism commonly damaging cotton, and no extensive damage from this disease has been definitely identified.

HARVESTING

When to Harvest

The castorbean crop should not be harvested until all the capsules on a particular spike have become dried and turned brown. No parts of the plant other than mature capsules should be included with the harvested beans, as green foreign material may promote molding and will cause difficulties in hulling. For this reason the capsules are removed from the spikes in the field rather than cutting the entire spike. After the capsules are mature, harvest should begin as soon as there appears to be any danger of loss from shattering or dropping, which will depend on the variety used and on the weather. Some varieties, particularly U. S. D. A. 74 and Conner, will require a hand harvest before the end of the growing season to prevent loss of seed or capsules from the early spikes.

Hand Harvesting

In the Midwest where the tall or intermediate types are grown, hand harvesting of castorbeans is practical to the extent that hand labor is available. In gathering the crop by hand the worker should use a 6- to 8-foot sack with a wire hoop fixed in the mouth to hold it open. The worker strips the capsules from the spike by drawing his cupped hands upward along the spike stem, and in one motion deposits the handful of capsules from each spike in the sack. Following this procedure skilled workers can harvest up to 1,000 pounds of seed in the hull per day.

Stripper Harvester[1]

A mechanical stripper-type harvester has been developed by the Nebraska Agricultural Experiment Station, and a two-row modification of this machine has been built by the United States Department of Agriculture in cooperation with the Oklahoma Agricultural Experiment Station. These machines reduce the cost of harvest and speed its completion in areas where large acreages of castorbeans are produced on fairly level land (fig. 7).

The stripper harvester operates on the beater principle, the machine having two opposed revolving beaters that flail the seed from the

[1] For further information on the stripper harvester, see Oklahoma Agricultural Experiment Station Bulletin B-376, An Experimental Castorbean Harvester, 1951.

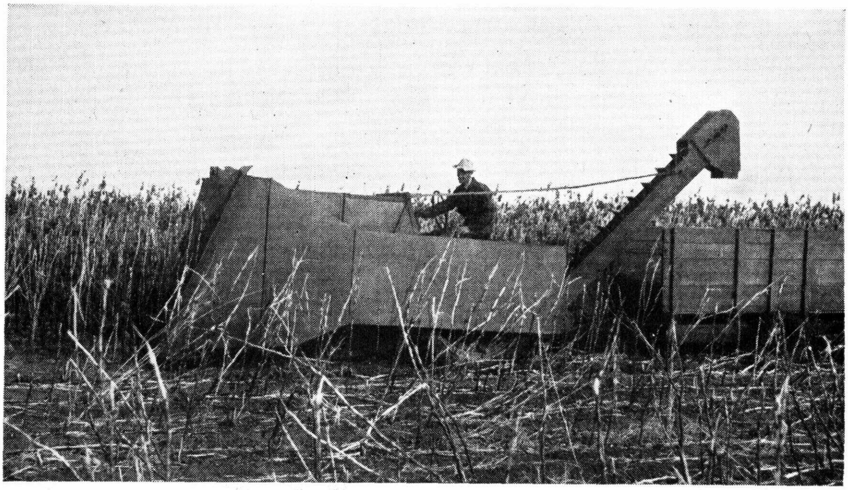

Figure 7.—Two-row stripper harvester in a field of U. S. D. A. 74 castorbeans.

plant as the machine passes along the row. The capsules are caught in conveyors and moved to the rear of the machine, where they are deposited in a tank or wagon. This harvester was originally developed for use on the tall- or intermediate-type plants, and redesign and development is still in progress with the machine (fig. 8).

Combine Harvester

One commercial company has modified its self-propelled peanut combine by removing the reel and substituting a row-gathering mechanism in its place (fig. 9). This machine does a satisfactory job of harvesting the short- or semidwarf-type varieties, although the har-

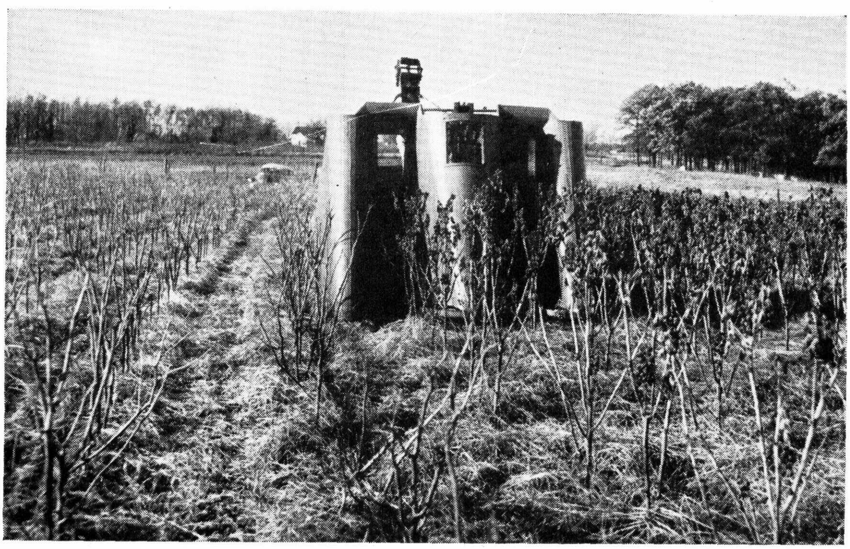

Figure 8.—Stripper harvester in a field of Cimarron castorbeans.

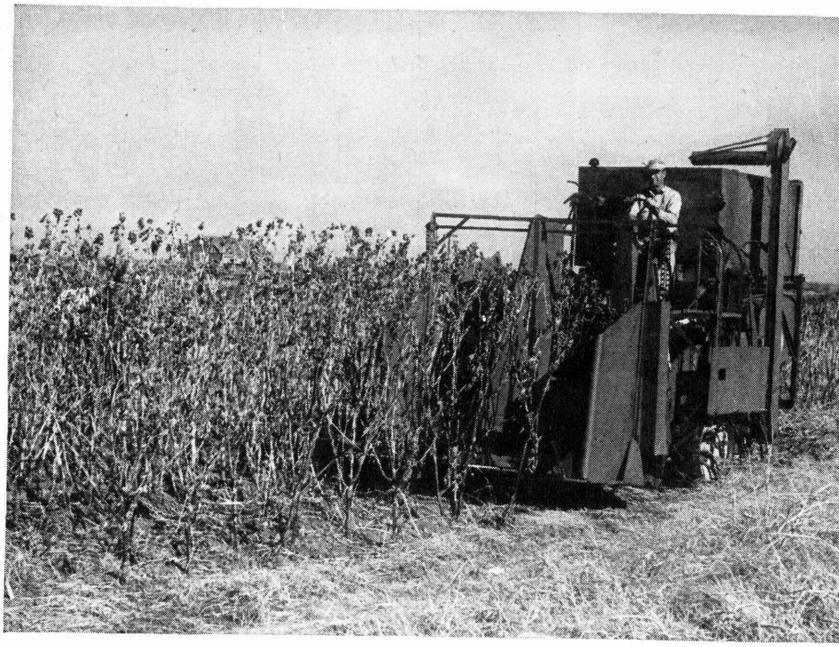

Figure 9.—Combine in tall castorbeans.

vesting rate in acres per hour is not so great as with the stripper-type harvester. The combine takes two rows at a time and removes the capsules from the plant, depositing the entire capsule in a tank on top of the machine. The cylinder, straw racks, and sieves in this machine are not adapted to harvesting other crops; hence, the machine cannot be changed over from a castorbean harvester to a small-grain combine without considerable time and expense.

Defoliation

Castorbeans can be defoliated, if necessary, using materials and methods similar to those used for the defoliation of cotton. However, defoliation is not recommended, unless the grower feels that to delay harvest further would result in undue loss from shattering or dropping or unless he requires the use of the land for some other crop. Reduced yields below the maximum possible in a full growing season usually result from defoliation.

HULLING

Types of Hullers

Castorbeans, whether harvested by hand, strippers, or combines, require hulling to remove the seeds from the capsule. This operation is performed by machines of various designs, all of which use the principle of rolling or rubbing the capsules in such a manner that the seeds are freed from the hulls. The seeds are then separated from the hulls by suction, sometimes with supplementary screening, to complete the separation. The machine most widely used at present removes

the hulls by passing the seed between two opposed rubber surfaces, one stationary and the other revolving. The capsules are fed through a hole in the center of the fixed disk and pass outward between the two rubber surfaces that rub or roll off the hull. The mixture of seed and hulls flows through an air separator that removes the hulls and dust, leaving the seed ready for shipment to the oil mill. Although this machine is still under development, it does a creditable job; sometimes seed delivered from the huller is sufficiently free of hulls and broken seed to be used as planting stock without recleaning. In other instances the seed must be recleaned with a fanning mill and the unhulled fraction rehulled. This type of huller, using one revolving and one fixed disk, has proved to be capable of higher capacities than the cylinder-type huller used in earlier operations.

Hulling Centers

In Oklahoma and Texas, castorbeans are grown over a large area. In order to facilitate the hulling operation, hullers have been set up in centers that roughly correspond to cotton gins or peanut-shelling plants. When the grower harvests his crop he takes it to the center (figs. 10, 11, and 12). There it is unloaded from his wagon by a suction unloader, fed through the hullers, and conveyed to scales where it is weighed. During weighing, a sample is removed for grading. Then the seed is either loaded directly into grain cars or stored for future shipment or for use as planting seed. The hulls are blown into elevated bins from which, if desired, they can be reloaded into the farmer's wagon or truck by gravity.

Field-Edge Hulling

In California and Arizona, and to some extent in the High Plains area of Texas, where higher acre yields are obtained and the production is more concentrated, hulling is done at the field edge (fig. 13). Combines are used exclusively at present in these areas. The system is as follows: The combine operator harvests a sufficient area to fill

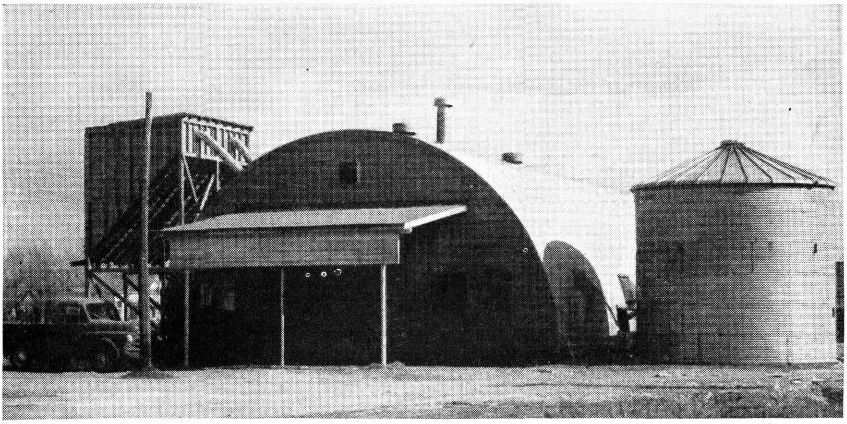

Figure 10.—*Hulling center, with hull bin at left and seed-storage bin at right. Suction unloader is under shed roof.*

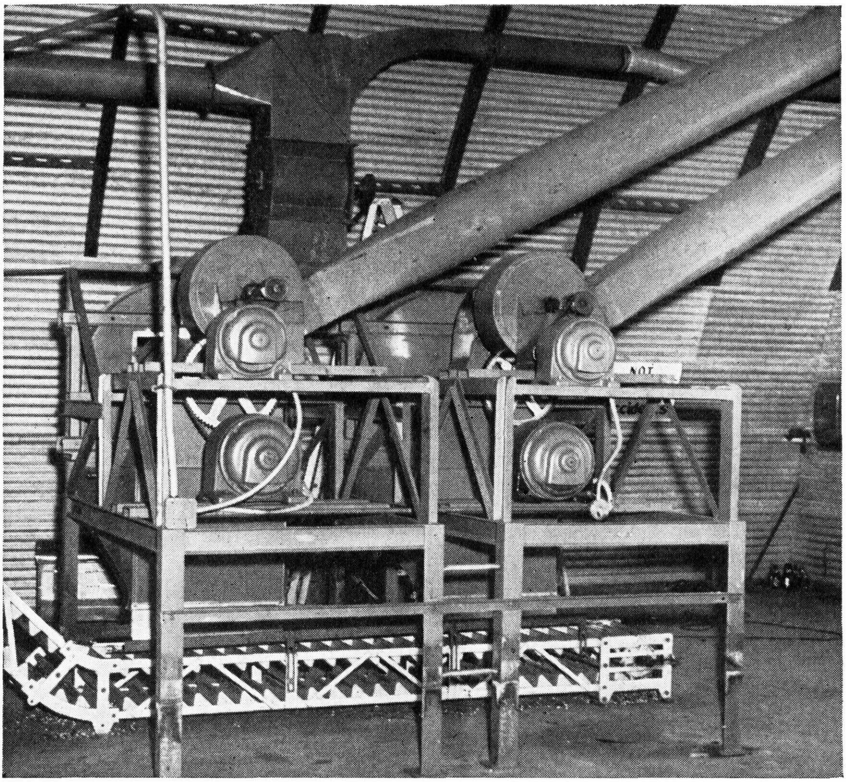

Figure 11.—*Two 36-inch hullers in stationary set-up: Large pipes carry hulls to hull bin and smaller pipes are pneumatic feeder.*

the bin on top of the combine, then drives to the huller, which is set up as a portable unit at the edge of the field, and dumps the load of beans on the ground or in a feeder bin from which the capsules are conveyed to the huller. After the beans are hulled, they are loaded in trucks and moved to the processing plant, either directly or through a collecting station, at which location they may be concentrated into carlots.

Grading

The seed harvested from various fields or varieties of castorbeans will vary in the amount of moisture, cracked and broken beans, and free or attached foreign material. Therefore, each lot delivered from the huller is graded for these three factors. In 1951 marketable castorbeans were permitted to have 6 percent moisture, any moisture above this figure being deducted from the gross weight. One-half of one percent of free and attached foreign material was permitted, the rest being deducted, and a maximum of 2 percent broken castorbeans was allowed, with one-third of the percentage above 2 being deducted from the gross weight. The grower was paid on the basis of the net adjusted weight of castorbeans. Minor changes in the grading procedure are likely as more experience is obtained.

Figure 12.—Cup conveyor from hullers to automatic scales (left). Cyclone cleaner (right) is part of pneumatic unloader system.

Figure 13.—Portable castorbean huller set up at field edge: The clean seed is deposited in trailer in background by air-conveyor system; the huller is fed mechanically.

MARKETING

At present castorbean oil mills or crushing plants are located only on the east or west coast of the United States. Since the cost of transporting the beans from the hulling center to the crushing plant is directly chargeable against the cost of castorbeans to the crusher, this freight rate is taken into consideration in adjusting the market price for various producing areas. Growers in California and Arizona who ship their seed to the mill in Los Angeles get a slightly higher price than do growers in Oklahoma and Texas, because it costs less to ship the oil by boat from Los Angeles to New York than to ship seed from the Midwest to New York by rail.

Other than the freight rate, the factors affecting the market price of castorbeans are the price of castor oil and the price of castor pomace. The price paid growers for clean hulled castorbeans tends to follow the price of these commodities.

In the past one company has purchased and crushed the major part of the domestic castorbean crop. Both this company and the Production and Marketing Administration (PMA) of the United States Department of Agriculture write production and purchase contracts for domestically produced castorbeans. If the grower's crop is not covered by a contract it is not eligible for sale to either of these agencies; hence, it is very important that the grower procure a Production and Purchase contract for his own protection before planting castorbeans.

USE AND DISPOSAL OF RESIDUES

Stalks and Leaves

Castorbean stalks have a high cellulose content that has been successfully utilized to produce cellulose and fiberboard. However, no company is at present making use of this process, as the costs of collecting the stalks and shipping them to the paper or cellulose plant seem to prevent it. Left in the field the stalks decay rapidly and are not difficult to cut up and work into the soil.

The leaves of the castorbean plant contain a material that has been shown to be toxic to many insects and which can be extracted and used as an insecticide. However, the cost of the collection and extraction of this material again prevents its use, and no such insecticide is being produced at present.

Hulls

Chemical analyses of samples of castorbean hulls show that they have fertilizer value exceeding that of cotton burs and roughly equivalent to fresh barnyard manure. Most castorbean growers feel that it is worth while to haul this material back to the farm and spread it on the fields from which it was taken or on other fields to which they wish to add organic fertilizer.

A ready market for hulls not returned to the farm has been found in selling them for application on lawns and gardens in some cities where the hulling centers are located. At other locations the entire stock of hulls accumulated at the hulling center has been taken by a commercial fertilizer manufacturer to be composted.

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